PATHOGENS AND GLOBAL HEALTH
2019, VOL. 113, NO. 6, 256–262
https://doi.org/10.1080/20477724.2019.1683326

Taylor & Francis
Taylor & Francis Group

Helminthiases in North Korea: a neglected public health challenge

Eunsuk Chang

Carolina Health Informatics Program, University of North Carolina at Chapel Hill, Chapel Hill, NC, USA

ABSTRACT

Helminthiasis is a neglected public health challenge threatening North Koreans. However, there is no precise estimate on the burden of helminthiasis in the region. This study therefore reviewed existing literature with the aim of analyzing the current state of helminthiasis among North Koreans, as well as highlighting the difference in the prevalence of helminthiasis between North Korean residents and refugees. All published resources citing helminthiasis among North Koreans were screened through the PubMed and a Korean bibliographic database as of April 2019. Official papers reported by the government and international agencies, as well as reports and books published in North Korea, were reviewed. After removing duplicated government reports, a total of 37 records were screened, and four were determined to be included for review. The total number of study subjects was 621 from the four eligible studies. Forty percent of them were refugees living outside North Korea. Total positive rate of any kind of helminths was 37.7%. *Ascaris* was the most widespread helminths with a prevalence estimate of 41.1%. The total positive rate of helminthiasis among residents living in North Korea was significantly higher than that among North Korean refugees (47.2% vs. 23.4%, chi-square p-value < 0.001). Poor hygiene, malfunctioning public health infrastructure, and feculent agricultural practices accounted for the spread of helminthiasis. Appropriate strategies and policies should be developed to prevent and alleviate helminthiasis in North Korea.

KEYWORDS

North Korea; Democratic People's Republic of Korea; helminth; intestinal helminthiasis; soil-transmitted helminth; parasites; refugee; systematic review

1. Introduction

Helminth parasites infecting humans and other animals reside not only in the gastrointestinal tract of their hosts but also in other parts of the body such as the lymphatic system. Nematodes (roundworms) and platyhelminths (flatworms) are two major phyla of helminths: nematodes include the major intestinal worms (a.k.a. soil-transmitted helminths) and filarial worms (infecting lyphatic system and soft tissue); platyhelminths include the flukes and tapeworms [1]. *Ascaris* and *Trichuris* belong to soil-transmitted nematodes, and they are transmitted by eggs present in human feces which contaminate the soil in areas where sanitation is poor [2]. Platyhelminth flukes include foodborne trematodes such as *Clonorchis sinensis* and *Paragonimus westermani*, which infect the bile duct and the lungs in humans, respectively, following the ingestion of uncooked fish or shellfish. *Taenia solium* (pork tapeworm) and sparganum are platyhelminth tapeworms that cause cysticercosis and lung nodules, respectively [3].

Parasitic helminths have long plagued humans globally. The WHO estimates about 1.5 billion people are infected by soil-transmitted helminths worldwide [4], resulting in 4.5 million DALYs (Disability-Adjusted Life Years) lost in 2016 [5]. However, the benefit of mass drug administration (MDA) campaigns using albendazole/mebendazole in endemic areas has decreased the burden suffered due to helminthiasis. Although the disease burden of helminthiasis is decreasing globally, the benefit of anti-helminth activity has been mostly concentrated in high- and middle-income countries, leaving the burden of helminthiasis underestimated worldwide [6].

Developing regions of East Asia have historically been endemic to helminths [7]. Helminths that are endemic to East Asia are soil-transmitted helminths (nematodes), platyhelminth flukes such as *Schistosoma* and *C. sinensis*, and *Taenia solium* [1]. The YLDs (Years Lived with Disability) caused by soil-transmitted helminths in East Asia are estimated to be 79,932 per 1,000 people from ascariasis and 18,199 from trichuriasis [8]. Among East Asian countries, North Korea (Democratic People's Republic of Korea) is suspected of having widespread endemics of helminthiasis due to the limited access to sanitation [9]. North Korea is one of the poorest countries in the world with an estimated nominal GDP of $1,013 per capita in 2015 [10]. The economic downturn of the socialist country, deteriorated by natural disasters and economic sanctions, led to the collapse of the state-operated public health system [11], particularly in terms of energy supply to healthcare facilities [12,13]. Although more than 80% of the population is covered by basic sanitation, according to the UN's Millennium Development Goals report, only 59% use flush toilets, many of which are obsolete

CONTACT Eunsuk Chang eunsukc@live.unc.edu Carolina Health Informatics Program, University of North Carolina at Chapel Hill, Chapel Hill, NC 27514, USA

due to the lack of purification treatment systems in operation [14]. This puts the population at an increased risk of being contaminated by parasitic eggs [14,15], as water, sanitation, and hygiene interventions are essential in the control of helminthiasis [16].

Helminthiasis in North Korea has received relatively little public health attention from the international community. Although important breakthroughs in data collection and investigation were made for the current status of nutrition, hepatitis B, and tuberculosis by researchers [13,17,18], no effort was realized on the subject of helminthiasis. However, it should be noted that helminthiasis is associated with or can aggravate other health problems, such as tuberculosis, malaria, HIV/AIDS, wasting, and anemia [19–24], which are prevalent in North Korea [5]. In this regard, it is essential for public health professionals working in North Korea to have knowledge about the current status of helminthiasis, since it would provide the rationale for the strategy on other important public health issues such as malaria and malnutrition in North Korea. This review, therefore, aims to analyze the current burden of helminthiasis in North Korea. In particular, the author will highlight the findings of helminthic cases both in North Korean residents and refugees (defectors) so that we can assess the differences in the epidemiologic conditions between the two populations.

2. Materials and methods

2.1. Study area

This systematic review will examine the prevalence of human helminthiasis in North Koreans. Other parasitic diseases such as malaria will not be discussed in this review. Filarial nematodes will not be covered because filarial worm infections such as lymphatic filariasis are not endemic and are thus not expected to be prevalent in North Korea [25].

2.2. Search strategy

Owing to its closed policy in terms of the release of information, statistics regarding North Korea are difficult to access. Health-related and demographic information is not openly shared with other countries because of the concern that international society could infer military power potential from the statistics. While the North Korean government has occasionally permitted South Korean or international organizations to investigate indigenous North Koreans' health, it is worthwhile to investigate the current status of helminthic diseases in North Koreans who relocated to South Korea or elsewhere; not only can we deduce the health status of North Korean residents from that of North Korean refugees, but we can also figure out the socio-environmental determinants of helminth dissemination by comparing the positive rates of helminths between the North Korean residents and refugees [26].

In search of the prevalence of parasitic diseases in North Korea, all published resources citing helminthiasis were identified through the PubMed and a Korean bibliographic database and were carefully analyzed as of April 2019 (Figure 1). The author used the following search terms for the PubMed: ('infectious diseases' OR 'communicable diseases' OR parasitosis OR helminthiasis OR helminthiases) AND ('North Korea' or 'Democratic People's Republic of Korea' or 'North Koreans') NOT (malaria [TI] OR plasmodium [TI]). Only those studies that cited North Koreans, either current residents in North Korea or resettled refugees from North Korea, were included for analysis. The author limited the dates of publication of the primary source research to no earlier than 2000, as the helminthic conditions could be influenced by the widespread use of human feces as fertilizer in response to the food shortage in the late 1990s [27]. The data were included only when they made reference to helminthic diseases, explicitly reported the number of study participants (denominator) and cases (numerator) so that test-positive rate could be estimated, and clearly disclosed epidemiologic and laboratory methods. There were no issues regarding translation error since many of South Korea's governmental reports written in Korean were also published in peer-reviewed international journals.

2.3. Statistical analysis

An individual may be infected with multiple parasitic species, which is a hallmark feature of helminth epidemiology [1]. As an analysis of individual-level data was not possible from the source literature, the author only counted the numbers of infected individuals to calculate total positive rates for each species, not considering multiple infections within an individual. Pearson Chi-squared test was used to compare the total positive rates of helminthiasis between North Korean residents and refugees. Statistical analysis was performed using R version 3.5.3 (The R Foundation for Statistical Computing, Vienna, Austria). A p-value of < 0.05 was considered statistically significant.

3. Results

A total of 37 records (after removing duplicated government reports) were retrieved from the search queries. After excluding 32 irrelevant records, a total of five sets of data was included (Figure 1). One report, however, was not published at the request of the North Korean government [28]. Thus, four data sets were available for the final analysis, of which two surveyed North Korean refugees and the other two surveyed both the North Korean residents and

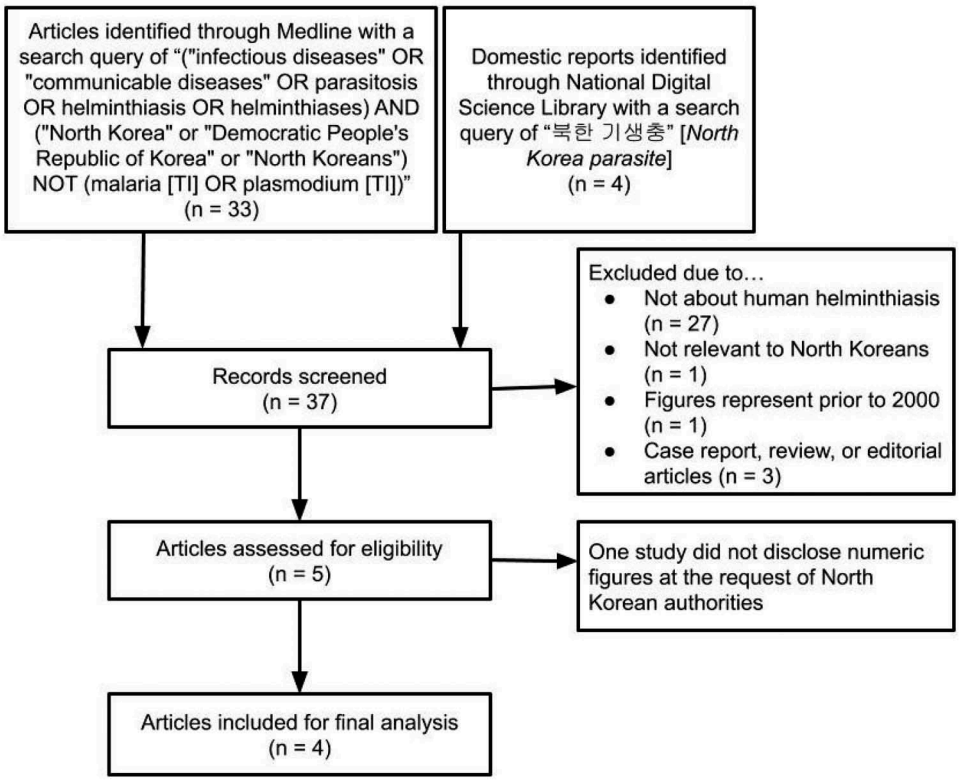

Figure 1. Flow diagram of the selection of articles.

refugees (Table 1). Two studies [29,30] gathered information from patients reporting any kind of symptoms that led to medical attendance, whereas the other two surveys were conducted upon healthy individuals for cross-sectional analysis. One study performed serum ELISA for food- and water-born helminthiasis (trematodes and spargana) [31], whereas the others examined stool parasites or reported colonoscopic findings.

The total number of study subjects was 621 from the four eligible studies. Approximately 38% of them were infected with at least one species of helminths. *Ascaris* was the most widespread helminth with an egg positive rate of 41.1%, followed by *Trichuris* with an egg positive rate of 38.1%. Approximately 54% (164/302) of North Koreans were infected with any kind of soil-transmitted helminths. About one-fifth (20.3%) of study subjects were tested positive for food- and water-borne helminths; *C. sinensis* was the most common among them with a total positive rate of 11%.

From the four studies, 40% of subjects were refugees (defectors) living outside North Korea. The total positive rate for helminthiasis among residents living in North Korea was significantly higher than that among North Korean refugees (47.2% vs. 23.4%, chi-square p-value < 0.001). Refugees living in Seoul, South Korea, had the lowest rate (13.5%) while the residents of North Korea rated the highest (57.6%) [29,32]. Although North Korean residents had a generally higher prevalence of helminthiasis than North Korean refugees did, except for *Taenia solium* metacestode, the differences in prevalence estimates were statistically different only in cases of *C. sinensis* and sparganum (chi-square p-values of < 0.001 and 0.002, respectively). No North Korean refugees were found to be infected with sparganum, whereas 8% of North Korean residents were ELISA-positive. No *Paragonimus* case was detected either in North Korean residents or refugees.

In Li et al.'s study, rural residents were recorded to have higher egg-positive rates than urban residents in North Korea. The egg positive rates among the residents of Pyeongyang and Cheongjin (urban cities) were 13.3%, as compared with the rates of 61.5% among the residents of rural areas. The egg-positive rate among civilian residents was 64.7%, while that among military personnel was 28.3% [32].

4. Discussion

Parasitic endemics have long been rampant in the Korean Peninsula. In a 1951 study, the United States Armed Forces collected fecal specimens for a survey of helminthic infection in North Korean prisoners-of-war and South Korean civilians, finding the total positive rates of intestinal parasites were 97.5% and 94.5%, respectively [33]. During the Vietnam War, in which South Korea deployed over 300,000 soldiers, the prevalence of helminthiasis among Koreans overwhelmed that among Vietnamese, even though Vietnam was a country that had been considered an economic equal to South Korea in that time period [34]. In

Table 1. The summary of four studies that estimated the prevalence of parasitic diseases among North Koreans.

Author, year of publication	Dorman et al, 2017 [29]	Lee et al, 2018 [30]	Shen et al, 2007 [31]	Li et al, 2006 [32]	Total	
Year of survey	2011–2014	2009–2013	2007	2003		
Sample size	49	20	270	282	621	
Subjects	NKD in Canada	Female NKD who admitted to Gastroenterology deptartment. at a tertiary hospital in South Korea	137 NKR in Cheongjin, Hambuk (Chinese border) 133 NKD in South Korea	236 NKR in Hambuk (Chinese border) - 190 civilians - 46 soldiers 46 NKD in China	373 NKR (60.0%) 248 NKD (40.0%)	
Method	Attendance at a clinic; stool exam	Attendance at a clinic; colonoscopy (15 samples) or stool exam (10 samples)	Serum ELISA	Stool exam		
Results					**Total**	P-value
Ascaris	-	-	-	41.1% (116/282) in total 43.2% (102/236) in NKR 30.4% (14/46) in NKD	41.1% (116/282) in total 43.2% (102/236) in NKR 30.4% (14/46) in NKD	148
Trichuris	-	45.0% (9/20)	-	37.6% (106/282) in total 40.3% (95/236) in NKR 23.9% (11/46) in NKD	38.1% (115/302) in total 40.3% (95/236) in NKR 30.3% (20/66) in NKD	184
C. sinensis	-	5.0% (1/20)	11.5% (31/270) in total 19.7% (27/137) in NKR 3.0% (4/133) in NKD	-	11.0% (32/290) in total 19.7% (27/137) in NKR 3.3% (5/153) in NKD	<.001
Ts metacestode	-	-	9.3% (25/270) in total 8.0% (11/137) in NKR 10.5% (14/133) in NKD	-	9.3% (25/270) in total 8.0% (11/137) in NKR 10.5% (14/133) in NKD	619
Sparganum	-	-	4.1% (11/270) in total 8.0% (11/137) in NKR 0% (0/133) in NKD	-	4.1% (11/270) in total 8.0% (11/137) in NKR 0% (0/133) in NKD	002
P. westermani	-	-	0% in total 0% in NKR 0% in NKD	-	0% in total 0% in NKR 0% in NKD	
Total positive rate	22.5% (11/49)	50.0% (10/20)	21.5% (58/270) in total 29.2% (40/137) in NKR 13.5% (18/133) in NKD	55.0% (155/282) in total 57.6% (136/236) in NKR 41.3% (19/46) in NKD	37.7% (234/621) in total 47.2% (176/373) in NKR 23.4% (58/248) in NKD	<.001

NKD = North Korean defectors (refugees); NKR = North Korean residents; *C. sinensis* = *Clonorchis sinensis*; Ts = *Taenia solium*.

1970, Koreans in South Vietnam showed a total parasitic infection rate of 82.4%, while 64.6% of Vietnamese and only 26.1% of U.S. Forces were positive [35]. The overwhelming burden of helminths was attributed to the prevalent agricultural practices which involve the use of human excreta as manure on farmlands and the habits of eating raw fish and shellfish in the Korean Peninsula [34].

Since the 1970s, the South Korean government focused its public health capacity to eradicating parasitic infections through promoting the usage of chemical fertilizers in place of human excreta and improving access to sanitation facilities. From 1969 to 1994, nationwide control activities were targeted mainly at school-age children through implementing compulsory stool screening exercise for soil-transmitted helminths and mass chemotherapy program [36]. Quinquennial national surveys to examine the prevalence of helminth parasites in the general population were conducted from 1976 to 2004. As a result, the overall intestinal helminth egg positive rates plummeted from 63.2% to 3.7% during that period [37,38]. By specific prevalence estimates, the egg-positive rate of *Ascaris* has plunged from 55.4% in 1969 to 0.03% in 2014, while for *Tichuris* sp., the prevalence has fallen from 74.2% in 1969 to 0.2% in 2014 [39]. The Chinese liver fluke, *C. sinensis*, was still found in 5.1% of the South Korean population and contributed to 77% of total egg-positives in 2014. This prevalence is ascribed to the ingestion of undercooked freshwater fish in endemic areas along the large rivers such as the Han River and Nakdong River [38,39].

This successful strategy of parasite control, however, was not able to reach the northern part of the Korean Peninsula. The shortage of medical commodities and incapacitated maintenance of infrastructure paralyzed the prevention and surveillance of communicable diseases in this region [11]. Infection control was undermined by inadequate running water and electricity. At lower-level health care facilities, poor management practices and a lack of adequate tools for monitoring infectious diseases have also been reported [40].

According to the United Nations Office for the Coordination of Humanitarian Affairs, 25% of North Koreans could not receive essential health services and 1.7 million children were at risk of fatal childhood diseases [41]. The WHO reported that only 60% of the population could uninterruptedly access essential drugs and medicines from 1995 to 1996, and the rate further declined to 46% from 1999 to 2002 after going through the great famine [18]. The North Korean government could cover only 46% of the pharmaceutical needs in 1999–2000, down from 60% coverage in 1995–1996 [18].

From 2011 to 2015, North Korea had imported $104 million's worth of medical supplies from abroad, 91.5% of which were pharmaceutical products [42]. The economic sanctions imposed in 2017 brought about the shortage of pharmaceutical resources, which led to the widespread usage of black-market drugs resulting in serious side effects [43]. In response to the scarcity of medicines, public health authorities encouraged the use of Koryo-yak, traditional herbal medicines, to supplement the insufficient supply of basic drugs. The ingredients were herbs and plants that grow naturally and were easy to harvest throughout the country. For example, they recommended sea wormwood (*Artemisia maritima*), the fruits of common carpesium (*Carpesium abrotanoides*), honey, rice straw, pumpkin seeds, or watermelon seeds for ascariasis [44].

International communities gave humanitarian aid to North Korea to alleviate the rampant epidemics of communicable diseases, but their efforts were concentrated on vaccine-preventable diseases such as tuberculosis, malaria, hepatitis B, measles, and rubella [13,18]. While North Korean authorities designated parasitosis as the second-most threatening challenge to the people of North Korea, the WHO did not list parasitosis in the Country Cooperation Strategy [18]. This discrepancy came from the notion that the WHO focused on improving the efficacy of government functions while the North Korean Ministry of Public Health was interested in controlling diseases [18,45].

By social demography, rural residents in North Korea were infected by helminths more than urban residents. Higher prevalence of helminthiasis in rural areas was also noted in South Korea, where 6.8% of rural residents were egg-positive whereas only 3.1% of urban residents were egg-positive in 2005 [46]. This socio-geographic determinant of parasitic infections also falls to the country of residence. The current finding showed that the North Korean defectors living in South Korea and Canada rated lower prevalence than residents in North Korea. This indicates that the distribution and incidence of helminthiasis are determined by socio-environmental variations that either favor or are hostile to parasitization during the course of resettlement. For example, North Korean refugees living in South Korea are provided with public health insurance which grants access to free medical services for the first five years of entry to South Korea [47]. The improved access to medical resources, in addition to clean water and better sanitary conditions in South Korea, may have played a significant role in reducing the burden of helminthiasis among North Koreans who resettled in South Korea.

One of the most interesting findings from Li et al.'s study is the lower prevalence of helminthiasis among the military population compared to the general population, which implies possible anti-helminthic activity targeting soldiers who are of a privileged social class owing to its 'military first' policy. However, the military medical system in North Korea is also devastated and has been working inefficiently

since the 1990s with facilities' and equipments' condition below international standards. Many North Korean defectors testify that the level of satisfaction toward the military medical system is low due to the lack of pharmaceutical resources, the inadequate supply of electricity, and the filthiness of facilities [48]. Although egg-positive rates in the North Korean military population were lower than their civilian peers in the study of Li et al. [32], interrupted measures against parasitosis, possibly due to the lack of pharmaceutical resources, may not have succeeded in restraining parasitosis in the military.

Infection with helminths do not only have negative impacts on physical health but also on the socio-economic development of affected populations, especially vulnerable school-age children. The WHO estimated that 5.2 million children aged 1–14 years require preventive chemotherapy to control helminthiasis in North Korea in 2016 [49]. This highlights the need to deliver a systematic and continuous preventive approach that covers preschool- and school-aged children, as well as adults.

In conclusion, helminthiasis is still prevalent in North Korea due to agricultural practices, poor sanitary conditions, and a dearth of available health care resources, which came from the economic downturn of the country. The higher helminth burden among North Korean residents compared to North Korean refugees implies that socio-environmental determinants of parasitization play an important role in the prevalence of helminthiasis. Helminth infections are a neglected public health challenge threatening both present and future generations in the northern part of the Korean Peninsula. Efforts should be made to establish strategies and policies to prevent and alleviate the possible resurgence of helminthiasis endemics to North Korea.

Disclosure statement

No potential conflict of interest was reported by the author.

Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

ORCID

Eunsuk Chang http://orcid.org/0000-0002-1350-3606

References

[1] Hotez PJ, Brindley PJ, Bethony JM, et al. Helminth infections: the great neglected tropical diseases. J Clin Invest. 2008;118(4):1311–1321.
[2] World Health Organization. Soil-transmitted helminth infections. 2019 [cited 2019 Aug 19]. Available from: https://www.who.int/news-room/fact-sheets/detail/soil-transmitted-helminth-infections
[3] Castro GA. Helminths: structure, classification, growth, and development. In: Baron S, editor. Medical microbiology. 4th ed. Galveston, TX: University of Texas Medical Branch at Galveston; 1996. 1023–1034. Available from: http://www.ncbi.nlm.nih.gov/books/NBK8282/
[4] World Health Organization. Soil-transmitted helminth infections – fact sheet. Geneva, Switzerland; 2016. Available from: http://www.who.int/mediacentre/factsheets/fs366/en/
[5] World Health Organization. Global health estimates 2016: disease burden by cause, age, sex, by country and by region, 2000–2016. Geneva, Switzerland; 2016. Available from: http://www.who.int/healthinfo/global_burden_disease/estimates/en/index1.html
[6] Jourdan PM, Lamberton PH, Fenwick A, et al. Soil-transmitted helminth infections. Lancet. 2018;391:252–265.
[7] London Applied & Spatial Epidemiology Research Group. Global atlas of helminth infections. 2019 [cited 2019 Aug 13]. Available from: http://www.thiswormyworld.org/
[8] Pullan RL, Smith JL, Jasrasaria R, et al. Global numbers of infection and disease burden of soil transmitted helminth infections in 2010. Parasit Vectors. 2014;7(1):37.
[9] CNN. What parasitic worms in defector reveal about North Korea. CNN. 2017 [cited 2019 Aug 14]. Available from: https://www.cnn.com/2017/11/22/health/north-korea-defector-parasites-health/index.html
[10] Silberstein BK North Korean GDP per capita over $1,000 for the first time ever last year, says Hyundai. North Korean Economy Watch. 2017 [cited 2019 Jul 22]. Available from: https://web.archive.org/web/20170108045819/http://www.nkeconwatch.com/category/statistics/gdp-statistics/
[11] Jo SE. *Bukhan Bogeonuiryo Bunya-ui Byeonhwa-wa Jeonmang* [Outlook for public health in North Korea]. Public Health Welf Issue Focus. 2019;361:1–8.
[12] Grundy J, Moodie R. An approach to health system strengthening in the Democratic People's Republic of Korea (North Korea). Int J Health Plann Manage. 2009;24(2):113–129.
[13] World Health Organization. WHO country cooperation strategy 2014–2019: Democratic People's Republic of Korea. Pyongyang, Democratic People's Republic of Korea: Country Office for DPR Korea, World Health Organization; 2016. Available from: https://apps.who.int/iris/handle/10665/250298
[14] Making it happen: technology, finance and statistics for sustainable development in Asia and the Pacific. Bangkok, Thailand: United Nations Economic and Social Commission for Asia and the Pacific; 2015.
[15] Hwang N. Identification of health indicators based on the 2008 census of population in DPR Korea. Health Welf Policy Forum. 2010;169:76–88.
[16] Strunz EC, Addiss DG, Stocks ME, et al. Water, sanitation, hygiene, and soil-transmitted helminth infection: a systematic review and meta-analysis. PLoS Med. 2014;11(3):e1001620.
[17] Park JJ, Shin HY, Atun R. Global health engagement with North Korea. Br Med J. 2018;361. Available from: http://search.proquest.com/docview/2052560169/abstract/E88CC84C1D5D42D9PQ/1

[18] World Health Organization. WHO country cooperation strategy 2004–2008: Democratic People's Republic of Korea. Geneva, Switzerland: Word Health Organization; 2003.
[19] Marais BJ, Lönnroth K, Lawn SD, et al. Tuberculosis comorbidity with communicable and non-communicable diseases: integrating health services and control efforts. Lancet Infect Dis. 2013;13(5):436–448.
[20] Martins-Melo FR, Ramos AN, Alencar CH, et al. Epidemiology of soil-transmitted helminthiases-related mortality in Brazil. Parasitology. 2017;144(5):669–679.
[21] Elias D, Britton S, Kassu A, et al. Chronic helminth infections may negatively influence immunity against tuberculosis and other diseases of public health importance. Expert Rev Anti Infect Ther. 2007 Jun;5 (3):475–484.
[22] Nacher M, Singhasivanon P, Yimsamran S, et al. Intestinal helminth infections are associated with increased incidence of Plasmodium falciparum malaria in Thailand. J Parasitol. 2002;88(1):55–58.
[23] Stephenson LS, Latham MC, Ottesen EA. Malnutrition and parasitic helminth infections. Parasitology. 2000;121(Suppl):S23–38.
[24] Molla E, Mamo H. Soil-transmitted helminth infections, anemia and undernutrition among schoolchildren in Yirgacheffee, South Ethiopia. BMC Res Notes. 2018;11 (1):585.
[25] Padmasiri EA, Montresor A, Biswas G, et al. Controlling lymphatic filariasis and soil-transmitted helminthiasis together in South Asia: opportunities and challenges. Trans R Soc Trop Med Hyg. 2006 Sep 1;100(9):807–810.
[26] Nishiura H, Lee H, Yuan B, et al. Infectious disease risks among refugees from North Korea. Int J Infect Dis. 2018;66:22–25.
[27] Newsweek. Kim Jong Un may have caused a parasitic worm epidemic in North Korea by making farmers use human feces on fields. Newsweek. 2017 [cited 2019 Aug 18]. Available from: https://www.newsweek.com/kim-jong-un-may-have-caused-parasitic-worm-epidemic-north-korea-making-farmers-714571
[28] Chai JY Control of intestinal parasites of North Korean people by transfer of South Korean technology and strategy. Ministry of Education, Science and Technology. Republic of Korea: Seoul National University College of Medicine; 2008. (Report No.: 800–20080570). Available from: http://www.ndsl.kr/ndsl/search/detail/report/reportSearchResultDetail.do?cn=TRKO200900074351
[29] Dorman K, Bozinoff N, Redditt V, et al. Health status of North Korean refugees in Toronto: a community based participatory research study. J Immigr Minor Health. 2017;19(1):15–23.
[30] Lee YI, Seo M, Kim SB. Infections of soil-transmitted helminth in refugees from North Korea. Korean J Parasitol. 2018;56(3):291–294.
[31] Shen C, Li S, Zheng S, et al. Tissue parasitic helminthiases are prevalent at Cheongjin, North Korea. Korean J Parasitol. 2007;45(2):139–144.
[32] Li S, Shen C, Choi MH, et al. Status of intestinal helminthic infections of borderline residents in North Korea. Korean J Parasitol. 2006;44(3):265–268.
[33] Brooke MM, Swartzwelder C, Payne FJ, et al. Intestinal parasite survey of Korean prisoner-of-war camp. U S Armed Forces Med J. 1956;7(5):708–714.
[34] Harrison M, Yim SV. War on two fronts: the fight against parasites in Korea and Vietnam. Med Hist. 2017;61(3):401–423.
[35] Kim JH, Yoon JJ, Lee SH, et al. Parasitological studies of Korean forces in South Vietnam, II. A comparative study on the incidences of intestinal parasites. Korean J Parasitol. 1970;8(1):30–35.
[36] Choi MH, Yu JR, Hong ST. Who neglects neglected tropical diseases? - Korean perspective. J Korean Med Sci. 2015;30(Suppl 2):S122–30.
[37] Hong ST, Chai JY, Choi MH, et al. A successful experience of soil-transmitted helminth control in the Republic of Korea. Korean J Parasitol. 2006;44 (3):177–185.
[38] Korea Association of Health Promotion. Prevalence of intestinal parasitic infections in Korea - 7th report. Seoul, Republic of Korea: Korea Centers for Disease Control and Prevention; 2004.
[39] Cho SH, Shin HE, Lee SE, et al. Survey on the prevalence of intestinal parasitic infections in Korea, 2014. Public Health Wkly Rep KCDC. 2016;9(7):118–124.
[40] Hwang NM. Strategies of communicable diseases control to North Korea on the preparation for Korean reunification. Health Soc Welf Forum. 2011;180:82–93.
[41] UN OCHA. 12 forgotten crises to remember. Medium. 2017 [cited 2019 Aug 6]. Available from: https://medium.com/humanitarian-dispatches/12-forgotten-crises-to-remember-b164508ae7ac
[42] Medical Aid for Children. *Joseon-ui Uihak Haksulji-reul Tonghae Bon Bukhan-ui Bogeonuiryo Ihae* [Understanding North Korea's Public Health and Medical Systems through North Korean Medical Journals]. Seoul, Republic of Korea: Medical Aid for Children; 2018.
[43] Hwang NM, Lee SS, Lee SY. The status of health, childbirth and child rearing of North Korean people. Sejong, Republic of Korea: Korea Institute for Health and Social Affairs (KIHASA); 2012. p. 80.
[44] Cheon E. Gajeong-eseo Koryo-yak hwalyong [The Usage of Koryo-yak in Households]. 2nd ed. Pyeongyang, Democratic People's Republic of Korea: Uihak Gwahak Publisher; 2014. 147–250.
[45] Hwang NM. National health priorities and key issues in Democratic People's Republic of Korea. Health Soc Welf Forum. 2004;89:37–50.
[46] Korea Centers for Disease Control and Prevention. Prevalence of intestinal parasitic infections in Korea - 7th report. Korea Centers for Disease Control and Prevention. 2005 [cited 2018 May 18]. Available from: http://www.cdc.go.kr/CDC/intro/CdcKrIntro0201.jsp?menuIds=HOME001-MNU1154-MNU0005-MNU0011&cid=8113
[47] Government of the Republic of Korea. Medical assistance to North Korean refugees. Jeongbu24. 2019 [cited 2019 Aug 11]. Available from: https://www.gov.kr/portal/service/serviceInfo/WII000001290
[48] Kwon MO, Kim HW, Yu JA, et al. Military healthcare system of North Korea. J Mil Nurs Res. 2016;34(2):1–11.
[49] World Health Organization. Soil-transmitted helminthiasis: countries x indicators. Geneva, Switzerland; 2016 [cited 2018 Feb 19]. Available from: http://www.who.int/neglected_diseases/preventive_chemotherapy/sth/db/?units=minimal&region=SEAR&country=prk&countries=prk&year=2016